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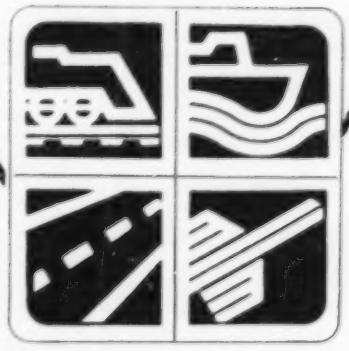

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LONG COMBINATION VEHICLES IN QUEBEC AND ONTARIO

A Report to
the Economic Analysis Directorate
Policy and Coordination Group
Transport Canada

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NOTE

This report is released as a contribution to the public discussion of an important issue in Canadian transportation. The contents reflect the views of the authors and not necessarily the views or opinions of Transport Canada.

SUMMARY

This research investigates the economic feasibility of allowing long truck combinations (over 30 metres) to operate on Quebec and Ontario four (or more) lane divided highways. These trucks already operate in Quebec, three other Canadian provinces, and 18 US states. The mechanism for allowing them, "special permits," can be used to control every aspect of their operations (time of day, mechanical conditions, routing, driver qualifications, etc.) The long truck combinations investigated operate at the existing axle and total truck weight limits.

There is a potential market of between six and ten million tonnes of freight for these trucks, including 1.5 to 2.9 million tonnes that would shift from the railways. This freight is light-density -- less than 400 kilograms per cubic metre, with most of the advantage going to freight under 200 kilograms per cubic metre (13 lbs/ft^3).

This freight could be moved at significantly lower costs on these long trucks; savings of over 30 percent are possible for some freight (the lightest density, the longest haul). The offsetting costs to the road system are non-existent or minimal. The one exception to this is where some roadway improvements may be required for access roads or ramps; it is suggested that permit holders pay for these costs.

Some issues were not investigated or require further study. Road safety was not investigated as Canadian data is poor. The related subject of vehicle stability and control has been investigated recently by RTAC (the findings were generally positive). The possibility that some shippers may suffer because of the railways losing up to $96 million in revenues was also not investigated.

Nevertheless, the evidence thus far suggests that there are clear advantages for allowing these vehicles to operate. The total annual freight bill for the six to ten million tonnes of freight now moving by rail or conventional trucks would decrease by somewhere between $62 to $137 million dollars (depending on the specific density/length-of-haul characteristics of the traffic).

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1. INTRODUCTION

The object of this research is to investigate the economics of allowing long-combination-vehicles (LCVs) to operate in Quebec and Ontario. Three specific LCVs are contemplated:

Rocky Mountain double: a double-trailer combination consisting of a 45-foot semitrailer and a 28-foot pup trailer although it is increasingly appearing as a 48- plus 28-foot combination.

Turnpike double: either two 45- or two 48-foot semitrailers and/or trailers.

Triple: usually three 28-foot semitrailers and/or trailers (although three 27-foot pups may be more common in Canada).

Currently these vehicles operate on major highways in Quebec at a maximum registered weight of 62.5 tonnes for approximately ten months of the year. The scenario envisaged in this research is the year-round operation of these LCVs from Riviere du Loup-to-Windsor along all four- (or more) lane divided highways within this corridor at the current Ontario truck size limit of 63.5 tonnes. This Riviere du Loup-to-Windsor corridor, "the corridor," is shown in Figure 1.

The subjects investigated are as follows:

i. Flows: An estimate is made of the annual volumes of trucks and freight along the corridor.

ii. Productivity and Costs: Productivity and cost differences of conventional trucks and LCVs are estimated.

iii. Shifts: An estimate is made of freight shifts from conventional trucks to LCVs and from rail to LCVs.

iv. Highway Costs: The impact of LCVs on road costs (pavements, bridges, geometry, capacity) is discussed.

v. Transportation Costs: Freight (truck and rail) transportation costs are estimated along the corridor with and without LCVs.

vi. Road-User Taxes: The impact of LCVs on fuel and registration taxes is examined.

Subjects excluded from this research include:

i. Road-Handling/Performance: The handling and performance characteristics of LCVs have been investigated in both the United States and Canada; in particular, aspects of this subject were included in the recently completed RTAC/CCMTA study (Roads and Transportation Association of Canada and the Canadian Council of Motor Transport Administrators). [1] Other than noting some of the pertinent findings, this paper does not address these issues (the relative merits of various mechanisms

used to combine vehicles, the stability of different types of combinations, etc).

ii. Safety: Given the inconclusive nature of the available evidence, the assumption made here is that the safety record of LCVs is no different than that of conventional truck combinations. [2]

iii. Access and/or Staging: One issue that has to be resolved before LCVs are allowed to operate is how or where LCVs are permitted to assemble and dis-assemble: at staging areas alongside the four-lane divided highways? at terminals a certain distance from the highway given adequate access routes? if staging areas are required, who pays for them, who manages them? These subjects have not been investigated here.

iv. Road-Pricing: The issue of setting appropriate road-user charges for different types of vehicles is fraught with difficulties. Although the impact of LCVs on road-taxes is estimated, no attempt is made to address the broader question of the appropriate level of these taxes for various types of trucks, and, in particular, for LCVs.

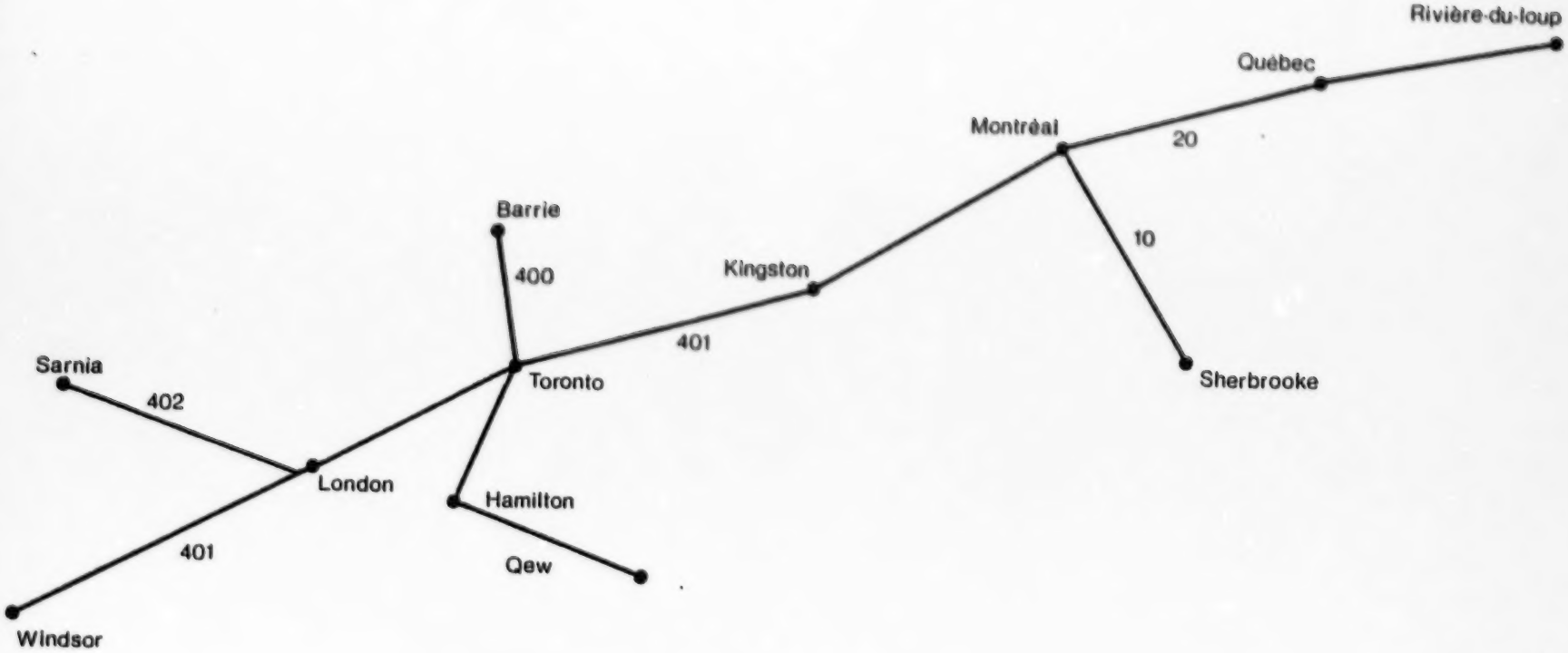

FIGURE 1 PROPOSED LCV CORRIDOR

2. BACKGROUND

2.1 Introduction

To understand the subject of LCVs operating on the Riviere du Loup-to-Windsor corridor, five background areas are examined. These are: the standard weight and dimension regulations which govern the operations of most trucks on the highways; developments in Ontario where a 1981 report recommended LCVs not be allowed; developments in the United States where a 1985 report recommended against a nationwide network of LCV highways; developments in Quebec where an experiment with LCVs starting in 1982 has been successful; and, recent national developments (the completion of the RTAC/CCMTA research) which although not addressing the issue of LCVs in detail, does provide favorable technical findings on their use.

2.2 Weight and Dimension Regulations

Provincial regulations governing the size and weight of trucks are complex. [3] Further, based on the findings of a major research program -- the RTAC/CCMTA "Canadian Vehicle Weights and Dimension Study" -- these regulations may be changing in the near future. Notwithstanding this complexity and this potential state of change, it is necessary to understand the regulations governing the size of most trucks in order that the dimensional aspects of LCVs are understood.

In Quebec and Ontario, any vehicle may operate under the standard regulations -- "standard" meaning the regulations apply to most vehicles under most operating conditions. The important aspects of these regulations are:

maximum dimensions			
height	4.15	metres	
width	2.6	"	
length			
- tractor	12.5	"	
- trailers - Que	14.65	"	
- Ont	12.5	"	
- semitrailer	14.65	"	(48'); Quebec allows longer under some conditions
- combinations	23.0	"	conditions govern the internal dimensions
maximum loads			
- front axle - Que	8.5	tonnes	
- Ont	9.0	"	
- single axles	10.0	"	
- tandem axles - Que	20.0	"	
- Ont	19.1	"	
- tri-axles	30.0	"	some 3-axle arrangements are limited to less than 30 tne
- gross vehicle weight ("GVW") - Que	57.5	"	
- Ont	63.5	"	

Given the nature of the regulations, there is almost an infinite variety of trucks that can operate within these limits: that is, infinite in terms of axle arrangements, loads, and spacings. However, for most general freight operations, there is a narrower range of typical configurations described in Section 3.

In addition to trucks operating under the standard weight and dimension regulations, there are a large number of vehicles operating under special permits. These permits may be for a single trip -- for example, a load of "indivisible" machinery that is wider than the 2.6 metres permitted under the standard regulations. Or, these permits may be for some other time period -- for example, in Ontario, most automobile haulers operate under annual special permits allowing loads higher than the standard 4.15 metres. These special permits are the mechanisms used to govern LCV operations in 22 provinces and US states.

2.3 Developments in Ontario

The Ontario Commission on Truck Safety (the Uffen Commission) was appointed in 1981. [4] Although it recommended some extension of the then 21 metre length limit for combination trucks (to 23 m), it recommended against the use of LCVs.

> "The present overlength vehicle regulations should NOT be changed, and overlength combinations, or those with more than three articulation points, should NOT be permitted in Ontario at this time." (p. 187)

The economic impact of allowing LCVs to operate was not investigated by the Commission and, hence, did not enter into its decision. Further, there have been many developments since the Commission conducted its inquiry -- the introduction of LCVs in Quebec, the expansion of LCV use in the three Prairie provinces (in some cases, Rocky Mountain doubles are now permitted on two-lane highways in Saskatchewan and Alberta), the completion of the FHWA study in the US, and the completion of the RTAC/CCMTA study in Canada. Possibly as a result of these developments, the industry has again (July, 1986) requested the Minister for permission to operate LCVs in Ontario. [5]

The Commission's reason for rejecting the use of LCVs was based on their road-handling characteristics: braking, rear-trailer amplification, acceleration and/or maintenance of speed on grades, splash and spray, wind blast, offtracking, and various other on-road aspects of handling and/or performance. The Commission writes:

> "Despite careful preparation by the owners and the use of exceptionally skilled drivers, all three of the overlength vehicles evaluated . . . failed fundamental off-road controlled tests and simple manoeuvering tests . . . under almost ideal conditions. All three units had unsafe brake timing. The car carrier [twin-trailer combination with a length of 35 metres] was so underpowered that it interfered with traffic and exhibited poor tracking. The . . . triple exhibited unsafe pitch and yaw trailer sway tendencies under

a variety of conditions. The . . . double had difficulty negotiating ramps and corners as well as exhibiting excess trailer sway under several types of maneuvers. It is obvious that further engineering improvements should be carried out on these vehicles, especially braking, and further tests made before such vehicles be considered for even special permit. There seems to be little justification to change the present regulations at this time . . ." (pp. 178 - 179)

These road-handling and performance problems are serious (the FHWA study and the RTAC/CCMTA study also found similar problems), but it should be noted that some of them can be over-come relatively easily (higher power-to-weight ratios, more experienced drivers, etc.). Others, such as braking systems or dolly designs, can be controlled to some extent. The Ontario trucking industry which performed these tests for Uffen maintains that it was their inexperience with LCVs that accounts in large part for the poor test results.

2.4 Developments in the US

The fact that 18 states now allow LCVs to operate creates pressures on Canadian jurisdictions, and in particular on Ontario to do likewise. The pressure arises from three factors. First, in considering weight and dimension regulations, there has been an historical tendency for the practice in one jurisdiction to be followed by other jurisdictions. Generally, a few states and/or provinces begin by allowing larger trucks to operate and this is followed by more and more states and/or provinces "joining the club." Quebec and Ontario have not been immune from this "joining the club" process -- as their relatively recent adoption of 48' length limits for semitrailers and 23 metres for combinations demonstrates. It is not unreasonable, therefore, to expect further developments. Second, the more jurisdiction (now 22 in total) permitting LCVs, the less validity there is to the claim by those who oppose their use that "not enough is known about LCVs." That is, the empirical evidence regarding aspects of LCV operations is growing. Third, as more jurisdictions allow the use of LCVs the pressure on (primarily Ontario) to keep the "cost of doing business competitive" grows. That is, manufacturers consider the local cost of transportation in their decisions to locate plants; these costs are affected by truck size.

A second development in the United States is the 1985 study by the Federal Highway Administration (FHWA) investigating the feasibility of developing an LCV network of highways. [6] This has a direct bearing on this research as the apparently negative findings cast doubt as to the advisability of allowing LCVs.

"There is no compelling reason for designation of a federally mandated LCV network at this time. The States are currently providing opportunities for controlled use of LCVs." (p. S-8)

However, this recommendation is not particularly germane to a discussion of the issues in Quebec and Ontario in that:

i. The changes contemplated in the US involve large increases in allowable weights as well as dimensions (GVWs on the interstate system in most places are 80,000 lbs., whereas the LCVs permitted by various states operate in the range of 120,000 to 140,000 lbs.) Ontario's consideration of LCVs only involves combination length considerations (ie, GVWs of 63,500 kg or 140,000 lbs. are already permitted in Ontario).

ii. The FHWA recommendation was based in part on a consideration of the individual State's current policies (ie, 18 currently permit LCVs). That is, the FHWA study does not make a blanket recommendation against LCVs.

iii. The American study examined different issues than those important to Quebec and Ontario -- the division of powers, responsibilities, and financing between federal and state governments. One of the reasons for its recommendation is the difficulty in implementing some of the conditions attached to LCV permits -- special driver qualifications, special vehicle requirements, and even time-of-day and/or weather-condition requirements. These become difficult to implement when several jurisdictions are involved. Few of these considerations have to be faced by Quebec or Ontario.*

iv. Finally, if it were not for the particular institutional (federal/state, state/state) and weight-related problems, few of which apply to Quebec or Ontario, the FHWA study would have been much more favorably disposed towards LCVs:

"It is clear that a network for LCVs would increase truck productivity and save energy. Freight costs could be reduced and transport competition increased . . . " (p. VI-17)

2.5 Developments in Quebec

Commencing in 1982, Quebec allowed LCVs to operate on four-lane divided highways under a system of special permits. This controlled experiment seems to have been judged a success, in that the joint task force created by the Department of Transportation and the Quebec Automobile Insurance Board ceased to monitor their operations in 1986. [7]

Under the experiment, LCVs were generally allowed to operate during a nine-month period, from March (or April) to December. Some restrictions were applied in November and December, depending on the weather and the road conditions. Other conditions imposed on the LCV operators included a ban on operations during peak traffic hours in

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* All provinces are rapidly implementing the National Safety Code which effectively takes care of some of the problems of concern to the authors of the FHWA study (eg, a linked data base on drivers so that each province has the means of determining who a qualified driver is under the terms of a special permit.)

Montreal and Quebec City and a ban on any operations from Saturday at noon to midnight Sunday.

Each operator was allowed four special permits; at the end of the experiment this was increased to eight. These permits were renewable on a three-month basis. This system of temporary permits was presumably used to put the burden of good behaviour on the trucking firms.

Four types of LCVs were permitted: the Rocky Mountain Double, the turnpike double in a nine-axle A-train configuration (3-S2-4), the turnpike double in a eight-axle C-train configuration (3-S2-3),* and the triple. With the exception of CP Trucks, which used the triple, all carriers chose the nine-axle A-train turnpike double. The maximum GVW was limited to 62,500 kgs. Each firm had to submit monthly a form giving the distance, the tare weight, the GVW of the LCV, and the amount of fuel consumed. The main highways used, all four-lane divided highways, were the Riviere du Loup-Montreal corridor, the Sherbrooke-Montreal highway and some other minor highways around Montreal and Quebec City. More recently a new four-lane divided highway between Montreal and Quebec on the north shore has been added.

During the experiment, the Department of Transportation undertook random technical checks to see if all safety and regulation of the Highway Code were correctly applied. In addition, each LCV had to have attached to the rear of the vehicle a sign reading "train routier," and maximum speed was limited to 90 km per hour.

Table 1 shows the increasing number carriers participating in the experiment. All but two of the for-hire carriers were general freight truckers; one of the others hauled household goods and the other hauled motor vehicles. The private carriers are a more heterogeneous group: retailing firms, the food industry, telecommunication firms, grocery stores and paperboard and wood products firms.

Table 2 describes the main characteristics of LCVs' operations. While the number of firms operating LCVs increased by a factor of seven, total LCV activity increased much more rapidly: total shipments increased 25 times and total weight increased by a factor of 26.7. Average weight per trip has remained relatively constant at about 21 tonnes. The average length of haul has continuously decreased since the beginning of the experiment, now averaging only 289 km. This suggests that many trucking firms are now operating LCVs on distance as short as 150 km.

Table 3 shows these same LCV characteristics on a monthly basis for 1984 and 1985. As shown, by 1985 LCV operations were fully integrated into the truckers regular operations: that is, with the exception of the first two months, LCV operations have stabilized at 42 to 50 thousand tonnes a month (or 2,000 to 2,500 trips per month).

---

* The first turnpike double (9-axle A-train) uses a two-axle A-dolly converter (single drawbar) on the second semitrailer; the second (8-axle C-train) uses a single-axle B-dolly converter (two drawbars).

	1982	1983	1984	1985	1986
Trucking firms	7	18	24	42	50
Private carriers	0	1	2	6	14
For-hire carriers	7	17	22	36	36

Source: Train Routier, Rapport d'activites, various years.

Table 1 LCV Operations in Quebec, Number of Firms

	1982	1983	1984	1985
Trips	699	4,149	11,650	17,574
Weight (kgs)	14,112,114	87,497,898	235,238,984	376,532,568
Average weight	20,189	21,089	20,192	21,426
Distance (km)	298,941	1,491,867	3,479,314	5,083,468
Average distance	428	360	299	289

Source: Train Routier, Rapport d'activites, various years.

Table 2 LCV Operations in Quebec, Trip Characteristics

	Trips	Weight (kgs)	Distance (km)	Daily trips	Weight /trip	Length /trip
1984						
April	715	15,447,617	241,612	36	21,605	338
May	1,372	26,898,208	389,846	69	19,605	284
June	1,321	26,631,224	396,420	66	20,160	300
July	1,364	26,515,962	420,618	68	19,440	308
August	1,816	36,772,590	552,805	91	20,249	304
Sept.	1,593	32,751,987	475,178	80	20,560	298
Oct.	1,829	36,935,775	490,130	91	20,195	280
Nov.	1,640	33,285,631	490,130	82	20,296	299
1985						
March	493	11,975,412	168,127	25	24,291	341
April	1,620	36,223,236	478,766	81	22,360	296
May	2,350	50,518,091	681,759	118	21,497	290
June	2,016	42,097,872	594,675	101	20,882	295
July	2,054	42,808,485	596,054	103	20,842	290
August	2,167	46,298,053	615,233	108	21,365	284
Sept.	2,289	49,443,686	645,299	114	21,601	282
Oct.	2,542	53,553,650	738,245	127	21,068	290
Nov.	2,023	43,614,083	565,310	101	21,559	279

Source: Train Routier, Unpublished 1984 & 1985 Rapport d'activites.

Table 3 LCV Operations in Quebec, 1984 & 1985

2.6 National Developments

The most significant national development has been the three-year research program by RTAC and the CCMTA. The work of this 2.8 million dollar study is now complete and a Committee has made recommendations for regulatory change. One of the areas of investigation was pavements and truck-axle loads; some of this is considered in Section 7.4.

A second area of investigation was vehicle stability and control. There is no specific mention of the LCVs in the final enunciation of regulatory principles. That is, the technical report ends with a list of "candidate regulatory principles." The fact that none of these excludes the use of LCVs is significant. The findings included seven measures for various aspects of stability, control, and offtracking. In comparing LCVs with the reference vehicle -- a standard five-axle tractor semitrailer -- the following findings are important:

i. "The Rocky Mountain doubles exhibit only modest limitations in all performance qualities, relative to the reference values, except in the case of low-speed offtracking performance." (p. 21) In other words, the Rocky Mountain double compares favorably to the standard five-axle tractor semitrailer; its one limitation is that it requires more room to turn at intersections (eg, on city streets).

ii. "The Turnpike Double exhibits high levels of dynamic performance that are tempered only by its inferior offtracking characteristics." (p. 21) As with the Rocky Mountain double, the turnpike double performs well in comparison to standard tractor-semitrailers -- again, there is a problem getting them around city intersections. The RTAC/CCMTA report continues:

"the use of turnpike doubles on turnpikes . . . , where easy access to breakdown areas is provided . . . , appears to be a practice which is in harmony with the findings on the total performance characteristics of this vehicle." (p. 21)

iii. "The C-train triples combination, particularly in the eight-axle version, holds promise for the future." (p. 20) In other words, while there are problems with current converter dolly designs, the authors feel there was a future potential for these configurations. A C-train, using a B-dolly converter, has three points of articulation versus five in a conventional A-train triple. The report continues:

"Firstly, the triple with the 8.2 m (27 ft) trailers is a particularly productive combination for the transport of low density freight. Secondly, the C-train implementation resolves most of the severe deficiencies in performance exhibited by the A-train triple while retaining the basic features of a general freight transportation system; namely, interchangeable trailers, detachable dollies, and van trailer configurations that can be conveniently loaded from the rear, at conventional loading docks. Nevertheless, in its current implementation,

> the C-train triple does exhibit a disturbingly high level of transient high-speed offtracking ["tail-wagging"] and is capable of oscillatory instabilities if unfavorable dolly steering properties prevail. Resolution of the remaining shortcomings, perhaps together with regulation of the steerable dolly to assure its performance qualities, would render the C-train triples attractive (simply considering productivity and dynamic performance)." (p. 20)

These technical findings were used to develop recommended weight and dimension regulations in June 1987. These are complex and the precise nature of the changes that will follow will not be known until the provincial and federal transport ministers reach some agreement. Three aspects of these recommendations can be noted here:

i. LCVs are not dealt with in detail. Rather, the suggestion is made that further work be done to develop appropriate standards for these vehicles. There is a hint, however, that triples are no longer considered acceptable (this is in contrast to the summary technical findings). There is a further implicit suggestion that Rocky Mountain doubles and turnpike doubles are acceptable under special permit situations. (p. 39)

ii. The committee recommended that standard combinations be allowed to operate at 25 metres in length (versus 23 metres in Quebec and Ontario now), and that semitrailers be allowed a length of 16.15 metres (53 feet) (versus the current 14.65 metres in Ontario and the 15.5 metres in Quebec). As a consequence, then, and <u>if</u> the recommendations are adopted, there will be <u>less</u> of a difference between "standard" trucks and special-permit trucks than is currently the case. That is, the "standard" trucks will increase from the current (typically) 48-foot single tractor-semitrailers and double 28-foot combinations to 53-foot singles and double 30-foot (plus) combinations.

iii. The prospect of double 30-foot combinations on the corridor may reduce the need for LCVs. However, there is an important caveat to the RTAC/CCMTA recommendations: only <u>B-trains</u> will be permitted to operate at lengths up to double 30-footers.* Given operational considerations,** a large segment of the trucking industry (eg, LTL carriers) will not switch to these larger units.

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* Strictly, B-trains will be permitted 20 metres from the front of the first semitrailer to the rear of the second semitrailer. Given typical swing clearances between the trailers, this will probably allow double 31-foot semitrailers.

** B-trains are best suited for dedicated, truckload hauling situations where semitrailers do not need to be assembled and dis-assembled.

3. CONFIGURATIONS

Although many types of trucks currently use the corridor, several account for most intercity general freight transportation.

First, for "weigh-out" commodities -- commodities such as steel coils or gravel that load a truck to the maximum allowable GVW limit before the dimensional limits in the regulations are approached -- both provinces allow multi-axle semitrailers and truck-plus-trailers. There are many varieties, but they need not be described here as weigh-out freight does not move in LCV configurations. That is, the proposed LCVs would operate under special permits which allowed greater lengths at the existing axle loads and GVW limits.

For the less dense general freight moving in vans -- for example, LTL freight -- current (and possible) configurations on the corridor are shown in Table 4.

	tractor-semitrailers				doubles	
Configurations	3-S2	3-S2 with drome	3-S3	3-S3 with drome	3-S1-2	3-S1-3 3-S2-3
Axles	5	5	6	6	6	7,8
Trailers (ft)	48'	48'	48'	48'	28'+28'	28'+28'
Linear space	48'	66'	48'	66'	56'	56'
GVW (tne)	41-46	41-46	51-56.7	51-56.7	50-57	60-63.5
Cube (m3)	99.4	136.2	99.4	136.2	115.3	115.3
(ft3)	3508	4809	3508	4809	4072	4072
Payloads (tne)	26-31	25-30	35-40	34-39	34-41	40-46
Optimal density						
- kg/m3	263-315	184-222	354-406	251-289	300-362	368-403
- lbs/ft3	16-20	12-14	22-25	16-18	19-23	23-25

Table 4 Typical and Possible Current Configurations

Configurations are indicated using the conventional symbols "3-S2" (etc): the first number refers to the axles on the tractor, "S" indicates a semitrailer, and subsequent numbers indicate the number of axles on semitrailers and/or full trailers. The doubles shown are known as "A-trains" as these are typical of general freight operations. For this discussion, it would not change things if these doubles were "C-trains" (it would matter, however, if they were B-trains as the tare weights would increase and, hence, available maximum payloads would decrease).

The two tractor-semitrailers shown in Table 4 with "dromes" are configurations with freight-carrying boxes added to the tractors frame. They are not common (there are operational disadvantages and possibly

higher tare weights than those implied in the figures in Table 4); nevertheless, they do exist and offer significant cube advantages over conventional tractor-semitrailers. Tractor-semitrailers with nine-foot or 12-foot dromes are more common; however, the ones shown in Table 4 have been pushed as far as the current dimensional limits in the regulations allow (roughly 18 feet).*

On the third and fourth lines, trailer lengths and total linear space available are shown (in the imperial units used by the industry). The GVWs shown on the fifth line and the payloads shown on line seven are typical given assumed tare weights:

tractors	-	8.6 tonnes
semitrailers, 1-axle, 28'	-	3.2 "
2-axle, 28'	-	4.1 "
2-axle, 48'	-	6.8 "
3-axle, 28'	-	5.2 "
3-axle, 48'	-	7.7 "

Factors such as sleeper units on the tractors, insulation, refrigeration units, etc. increase these tare weights.

Available cubes have been estimated assuming usable widths of 100 inches (2.54 m), usable heights of 106 inches (2.69 m) and usable trailers lengths of four inches less than the total trailer (eg, a 48' trailer has 572 inches). In practice, actual cubes will vary by a large margin depending on the trailer construction, the actual height of the trailer, the existence of insulation, etc.

	Rocky Mtn Double		Turnpike Double		Triple
Configuration	3-S2-2	3-S2-2	3-S2-2	3-S2-2	3-S1-2-2
Axles	7	7	7	7	8
Trailers (ft)	45'+28'	48'+28'	2 X 45'	2 X 48'	3 X 28'
Linear space	73'	76'	90'	96'	84'
GVW (tne)	63.5	63.5	63.5	63.5	63.5
Cube (m3)	150.8	157.0	186.2	198.7	173.0
(ft3)	5324	5545	6575	7017	6109
Payloads (tne)	44.2	44.0	41.7	41.3	43.5
Optimal density					
- kg/m3	293	280	224	208	251
- lbs/ft3	18	17	14	13	16

Table 5 Potential LCV General Freight Van Configurations

* The largest known drome in Ontario or Quebec operating under the current standard regulations is 18'4" in length.

Finally, "optimal density" shows the point at which freight either cubes out or weighs out on each configuration. Freight with a density of less than the values shown will fill the cube of the vehicle before the allowable load limits are reached (ie, it "cubes out"); and freight with a density higher than the values shown will load the vehicle to the allowable weights before the space in the van is filled (ie, it "weighs out"). In practice, actual freight can cube out with densities lower than those shown depending on loading characteristics (eg, freight which leaves a lot of air-space between boxes, pallets, or containers; or freight which cannot be top-loaded).

Comparable data for LCVs is shown in Table 5.

The points to note about both the current configurations and the LCVs are as follows:

i. The largest cube available for most general freight operations in Ontario today is about 115 m^3 (4,000 ft^3). This can be increased somewhat by those operators who chose to use dromes (relatively rare) or certain other devices (eg, drop-frame trailers).

ii. The use of LCVs would increase the cube available by about 31 to 72 percent: that is, the smaller Rocky Mountain double has roughly 31 percent more cube than current doubles, and the turnpike double with up to 199 m^3 (7017 ft^3) offers 72 percent more cube than current double 28-foot pups.

iii. Freight that would benefit the most with LCV operations would have a density of about 208 kg/m^3 (13 lbs/ft^3) or less. However, all freight with a density of roughly 400 m^3 (25 lbs/ft^3) or less would experience some benefit. ("Benefit" here simply means more load per truck trip.)

4. FLOWS

4.1 Introduction

In this section estimates are developed for the flow of trucks and freight along the corridor. Although this is a complex task involving less-than-perfect data sources and many assumptions, it is a necessary step in the evaluation of the potential importance of LCVs.

4.2 Statistics Canada Data: A Broad Overview

The best data on commodity flows is Statistics Canada's For-hire Trucking Survey and, for the last two years, the associated commodity data from the larger private truckers (firms with 15 or more trucks). [10] This is shown in Table 6.

As shown, there was a potential freight flow over the corridor of 136.7 (1984) and 151.9 (1985) million tonnes: this is the sum of all cells on the matrices except the Atlantic-Atlantic and the West-West. This assumes, unrealistically, that all freight with an origin or destination in Quebec or Ontario and all freight passing through the two provinces (eg, West to Atlantic) moves on the corridor.

There are problems with these estimates: Statistics Canada does not survey all truck activity (international movements, movements by private carriers with less than 15 trucks, and some for-hire movements such as courier are missing); the data is not directly convertible to truck trips; and, it is not possible to use the data directly to determine how much of this commodity flow occurred on the corridor (the four-lane, divided highway system) versus the flow that occurred off the corridor.

		Destination			
Origin		Atlantic	Quebec	Ontario	West
1984	Atlantic	14.6	0.8	0.4	*
	Quebec	0.8	37.8	5.5	0.3
	Ontario	0.5	7.1	81.0	1.2
	West	*	0.3	1.0	66.9
1985	Atlantic	17.1	0.7	0.5	*
	Quebec	0.8	49.4	6.6	0.3
	Ontario	0.7	5.8	84.5	1.3
	West	0.1	0.3	1.1	65.1

Source: Statistics Canada
* less than 0.1

Table 6 For-hire & Private Truck: Total Commodity Flows, 1984/85
(millions of tonnes)

From Statistics Canada's data, in Ontario in 1985 for Class I and II for-hire carriers, 53 percent of all originating freight and 62 percent of all destination freight was accounted for by seven large metropolitan areas on the corridor. In Quebec, the comparable figures for the three metropolitan areas on the corridor were 40 percent of all originating and 42 percent of all destination freight. In other words, the four-lane divided highways linking these large cities account for most of the truck freight in the two provinces. If the smaller towns along the corridor could be added (these are not shown separately in the published statistics), it may be that as much as three-quarters of all truck freight moves over the corridor (at least for a portion of its trip).

In its 1985 publication, Statistics Canada provides the results of a special survey of international carriers. While this only covers some carriers (for-hire carriers only, accounting for roughly 75 percent of international trucking revenues in 1985), it reveals something important about international trucking: most of the activity is between Ontario and the United States. Considering just the Quebec and Ontario activity, there were 711,699 Ontario-US truck trips by surveyed carriers versus only 42,319 Quebec international truck trips. Assuming comparable load factors, this suggests that international flows in Quebec are only six percent of those in Ontario.

4.3 Traffic Data: A Closer Look

In both Ontario and Quebec, AADTT ("average annual daily truck traffic") numbers are available from the provincial departments of transport. These indicate the number of trucks passing a given point on the corridor, but care has to be taken in using them as without information on trip characteristics (particularly the length of haul) it is difficult to translate these numbers into daily (or annual) measures of truck activity. The available AADTT data is shown in Tables 7 and 8.

	Westbound Trucks		Eastbound Trucks	
	all	combination	all	combination
To/From US - (Windsor/Sarnia)	2,832	2,434	2,610	2,247
Putnam	3,187	2,764	2,912	2,473
Streetsville	4,483	3,526	4,106	3,264
Bowmanville	3,401	2,941		
Whitby			4,556	3,716
Gananoque	1,955	1,812	1,797	1,634
Prescott	1,712	1,543		
Lancaster	645	521	1,754	1,553

Source: Ontario MTC [11]

Table 7 Ontario AADTT, 1983
(corridor movements only)

The information available from Quebec (Table 8) also shows that the mix of truck types was a follows:

	1983	1985
straight trucks	14.3%	5.3%
tractor-semitrailers	82.1	91.2
trains (2 pup trailers)	3.6	3.5

Furthermore, from the commodity information collected in the Quebec survey, it is possible to estimate that 21 percent of the trips carried LTL freight. (This is based on the author's examination of detailed commodity data from the survey.)

1983 Westbound Truck Trips			
Origin		Destination	
Greater Montreal	1,267	Ontario	1,461
Quebec Metro. Area	88	West	20
Atlantic	109	US	183
Other Quebec cities	202		
	1,666		1,666
1985 Eastbound Truck Trips			
Origin		Destination	
Toronto Metro. Area	819	Greater Montreal	1,523
West	18	Quebec Metro. Area	111
US	163	Other (Que/Atlan.)	342
Ottawa area	25		
Other Ontario	951		
	1,976		1,976

Source: Quebec MoT [12]

Table 8 Quebec AADTT, 1983 & 1985
(corridor movements at Quebec/Ontario border)

Another source of information from Quebec is the new weigh-in-motion scale near the Quebec/Ontario border (eastbound traffic). This suggests an average of 1,502 eastbound trucks, of which 1,164 were combination trucks, per day. This is based on data collected over a 207 day period (September 1986 to February 1987) and includes weekends and holidays. The mean payload estimated from this data is 13.9 tonnes.

To summarize, the available AADTT data suggests the following: if it is understood that the high AADTT figures in and around Toronto are accounted for by a high volume of local trucks (gravel trucks, garbage trucks, trucks making deliveries out of Toronto, etc.), then there appears to be something like 1,500 to 2,500 inter-city trucks moving on the corridor in each direction on the average day.

Before these AADTT can be used to estimate truck activity on the corridor, a problem has to be considered. Assume a hypothetical corridor 1,000 km in length with 10 observations posts spaced evenly 100 km apart. Each post observes 1,000 trucks a day moving in each direction. The question is, how much truck activity is there on the corridor?

With no further data, this question cannot be answered. Suppose, for example, the average length of haul is 1,000 km. Making other assumptions about where these 1,000 km occurred, it can be calculated that the corridor experienced 2,000 truck trips per day (1,000 in each direction). If the average load is 10 tonnes, total tonnage on would be 20,000. But suppose the average length of haul is less than 100 km. It is possible that the 10 observations posts observes 2,000 different trucks trips on each day. Total trips on the corridor would be 20,000 and with the same average load of 10 tonnes, the total tonnage on the corridor would be 200,000.

The point is that without information on trip characteristics, in particular, average length of haul, AADTT figures by themselves cannot be used to accurately estimate the flow of freight along a corridor.

4.4 Ontario 1983 Commercial Truck Survey

In 1983 Ontario conducted a special survey of truck traffic on its highways. [13] In this survey, the attempt was to create a snapshot of daily truck activity (trip, commodity, carrier characteristics, etc.). Some of the key information is as follows:

- Ontario highways experience 45,816 truck trips on the average day, and these trips account for 450,248 tonnes of freight.

- The total movement between Quebec and Ontario is as follows:

	trips	tonnes	average load
easterly	2,532	34,888	13.77 tne
westerly	2,134	24,763	11.60

  This includes more than just Quebec/Ontario freight (eg, it includes US-Quebec freight); and it includes more than just corridor traffic (eg, Ottawa/Hull).

- The mean payload is 9.8 tonnes considering all truck trips (ie, including empty), and 12.7 tonnes considering interprovincial trips only.

- About one-third of the trips carried potential cube-out freight (general freight, parcel, household goods, autos), another third carried potential weigh-out freight (bulk, dump, scrap, lumber & wood), and the remaining third were empty.

- The mean trip length was 345 km; and, 46.3 percent of all trips had a length of 200 km or more (p. 45).

- Of all trips, 41.8 percent were accounted for by tractor-semitrailers and/or trains (doubles) with van or automobile-carrying bodies (p. 18). These configuration/body types are the most likely to switch to LCV operations. However, these most likely candidates can be further reduced (from 41.8%) by noting that 7.8 percent of tractor-semitrailers and trains had seven or more axles (p. 19). Trucks with seven or more axles in Ontario are used to carry heavy dense freight.

- Of all trucks passing through a scale site during the survey, 77.5 percent were observed on corridor highways (50,911 out of 65,679). This is not a perfect statistic as it cannot be related to the expanded sample survey results. But it is the only one available to make any estimate as to how much of daily truck trips in Ontario occur on four-lane divided highways.

4.5 Summary: Estimated Flows

Table 9 contains a summary of the estimated truck activity:

- Line 1: Statistics Canada's figures indicate 151.9 million tonnes of freight moving by truck over Quebec and Ontario highways (Table 6).

- Line 2: Comparing the 1983 MTC data with the 1984 Statistics Canada data, a rough estimate of the missing flows in Statistics Canada (flows by private trucks with less than 15 trucks, etc.) is:

1984, StatsCan, total intra-Ontario traffic: 81.0 million tne
1983, MTC, intra-Ontario flows (278,762 X 365): 101.8 " "

The Statistics Canada data, it is assumed, under-estimates total domestic truck flows by roughly 25 percent.

- Line 3: The MTC data can also be used to make an estimate of international truck flows in Ontario. In 1983, international traffic (82,545 tonnes) were roughly 30 percent of intra-provincial traffic (278,762 tonnes). The figure shown on line #3 is 1.25 times Statistics Canada's estimate of 84.5 million intraprovincial tonnes in Ontario, all times 30 percent. An alternative estimate is 365 times MTC's 82,545 tonnes, equalling 30.1 million tonnes.

- Line 4: International flows in Quebec have been estimated at six percent of the Ontario figures (see Section 4.2).

- Line 6: Assuming figures in Quebec are similar to those in Ontario, something like 75 percent of all truck trips occur in whole or in part on corridor highways.

- Lines 7 and 8: Using an assumed 10 tonnes per trip, annual truck trips on the corridor are estimated at 16.76 million, or

45,918 per day (assuming 365 days is the appropriate figure for AADTT calculations). To check the calculations thus far, it might be noted that the 1983 MTC figures suggested 45,816 truck trips daily in the province of Ontario of which it is estimated (here) that three-quarters or 34,362 occurred on the corridor highways. The figure in Table 9 shows an estimate of 45,918 truck trips per day on the corridor in both Quebec and Ontario.

1. StatsCan, 1985, total Que/Ont flow (Table 6)	151.9
2. Add estimate of non-surveyed domestic flow (25%)	38.0
3. Add estimate of international flows in Ont (30% of intra)	31.7
4. Add estimate of international flows in Que (6% of Ont)	1.9
	====
5. Total truck freight flow, Que/Ont	223.5
6. Truck freight flow on corridor (75%)	167.6
7. Annual truck trips (assume 10 tonne loads)	16,760,000
8. Daily truck trips	45,918
9. Interprovincial tonnes	18.2
10. Annual interprovincial trips (assume 13 tonne loads)	1,400,000
11. Daily interprovincial trips	3,836

Table 9 Estimated Corridor Activity
(tonnes in millions, trips as shown)

- Lines 9, 10, and 11: To check these procedures for one observation point, the last three lines show only the interprovincial activity on the corridor (aside from Quebec-Ontario traffic, there is also Western Canada and Atlantic Canada traffic.) The 18.2 million tonnes shown in line #9 are taken directly from Table 6 (in other words, it is assumed that the 25 percent of non-surveyed activity by Statistics Canada is all intraprovincial). On line #10, annual truck trips are calculated assuming a higher load factor than in line #7 (see the Quebec and Ontario survey data). On line 11, daily interprovincial truck trips at 3,836 (roughly 1,900 in each direction) compare favorably with the actual AADTT data.

To summarize, then, out of a total annual movement of truck freight of 223.5 million tonnes in Quebec and Ontario, 167.6 million tonnes are estimated to move on the corridor (the four-lane divided highways) for some part of their movement. This movement represents 16.76 million annual truck trips. These 16.76 million trips include all commercial trucks (small straight trucks up to nine or more axle doubles) whether loaded or empty (the average load factor is only estimated at 10 tonnes -- but this includes approximately one-third of the trucks running empty).

5. PRODUCTIVITY & COSTS

The figures shown in Table 10 reflect a variety of operating conditions and a variety of computational differences. Some operational differences, fuel consumption figures, and some indication of the size of data base associated with these costs are shown in Table 11.

Shown on the first line are the US costs computed for the 1985 FHWA study. [14] These have been converted to Canadian costs at a rate of 1.30 (the FHWA study did not show costs for Triples).

	Tractor-semitr.	Double 28's	Rocky Mtn.	Turnpike double	Triple
FHWA (1982)	0.797	0.851	0.963	1.004	
Trimac (1986)					
- Que	0.926	1.023			
- Ont	0.903	0.995			
Carrier #1	0.800			1.021	
Carrier #2	0.802	0.814		1.007	0.945
Carrier #3	0.817	0.906			1.016
"Average"	0.804	0.857	0.963	1.011	0.981
- index (1)	100.0	106.5	119.8	125.7	122.0
(2)		100.0	112.4	118.0	114.5

Table 10 1985 Truck Costs
(linehaul costs per kilometre)

The figures shown in the second and third lines are standard Trimac costs (dry van, paved roads, 160,000 km annually) for single 45-foot semitrailers and double pup operations. [15] To make these more relevant to the present needs, several adjustments have been made. First, only vehicle-related costs have been used (no overheads or profit have been included). However, given the structure of the Trimac costing procedures there are some costs associated with vehicle-loading built into these figures which probably is one of the reasons the figures are higher than the others. Second, the figures have been adjusted for two-way hauls (the base figures assume empty returns) and 300 kilometre trips (Trimac's base figures assume one-way hauls of 160 km). All adjustment factors are provided in the source document.*

The next three lines of Table 10 contain the costs of various Canadian carriers operating LCVs. (As some of these carriers requested anonymity, no names have been shown.) The first operates in Western

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* One aspect of Trimac's procedures for adjusting for two-way hauls has not been followed (extra vehicle/driver costs associated with loading).

Canada and hauls very light-density freight (see Table 11). For a little more than a 25 percent increase in linehaul costs, this carrier has more than doubled its average payload (8.6 tonnes to 19.7). The second carrier operates LCVs in four provinces. The third operates triples in Alberta, and the fourth carrier (who could not supply figures for Table 10) operates Rocky Mountain and turnpike doubles in Western Canada.

At the bottom of Table 10, using some judgement as to how to combine the various information, "average" costs per kilometre for 1985 have been shown. Obviously individual operations could be considerably above or below these figures depending on a range of factors (input prices, freight characteristics, trip characteristics).

	Tractor-semitr.	Double 28's	Rocky Mtn.	Turnpike double	Triple
FHWA					
- trips				28	172
- average load				28.74	17.54
- density				193.8	126.6
- fuel consumption				67.2	52.3
Trimac - Que					
- average load	20.41	29.93			
- density	219.5	270.2			
- fuel consumption	45.9	48.0			
Trimac - Ont					
- average load	22.57	31.75			
- density	242.7	286.6			
- fuel consumption	43.5	45.4			
Carrier #1					
- trips				368	
- average load	8.6			19.69	
- density	92.6			105.8	
- fuel consumption	44.9			65.8	
Carrier #2					
- fuel cost as % of single 45'	100	100		125	119
Carrier #3					
- trips					315
- fuel consumption		35.9			42.6
Carrier #4					
- trips				143	
- fuel consumption	46.8		51.0	52.4	

Table 11 Truck Operating Characteristics
(loads in tne; density in kg/m^3; fuel consumption in L/100 km)

In Table 12, the costs of hauling freight on various configurations has been computed assuming freight with a density of either 100 kilograms per cubic metre or 200 kilograms/cubic metre. The "base" linehaul costs shown are from Table 10. To reflect more accurately the effect of load

on fuel consumption, these base linehaul costs have been adjusted according to the available empirical measures of fuel consumption. [16] Briefly, within the relevant range (ie, GVWs and operating speeds), for every tonne increase or decrease in payload, fuel consumption changes by one percent. Where fuel costs represent roughly 28 percent of linehaul costs (as they do with the configurations shown in Table 10), this translates into a 0.28 percent change in linehaul costs for every tonne above or below the average load. Average loads, in this case, have been assumed to be relevant for the base case linehaul costs.

	Tractor-semitr.	Double 28's	Rocky Mtn.	Turnpike double	Triple
Cube (m^3)	99.4	115.3	157.0	198.7	173.0
Payload (tne)					
- 100 kg/m^3	9.9	11.5	15.7	19.9	17.3
- 200 kg/m^3	19.9	23.1	31.4	39.7	34.6
Linehaul Cost ($/km)					
- base	0.804	0.837	0.963	1.011	0.981
- 100 kg/m^3	0.790	0.841	0.941	0.983	0.957
- 200 kg/m^3	0.818	0.873	0.985	1.039	1.005
Cost/cubic metre-km	0.008	0.007	0.006	0.005	0.006
Cost/tne-km					
- 100 kg/m^3	0.079	0.073	0.060	0.049	0.055
- 200 kg/m^3	0.041	0.038	0.031	0.026	0.029
Cost/unit of output					
- index (1)	100.0	91.8	75.8	62.8	70.0
(2)		100.0	82.5	68.4	76.2

Table 12 Truck Costs

To summarize, LCVs cost more to operate than current configurations (Table 10) -- 20 to 26 more than the standard five-axle tractor-semi-trailer, and 12 to 18 percent more than the current double 28's. However, for light-density freight, the cost per unit of payload decreases with LCVs. Considering turnpike doubles, with almost 200 cubic metres of space (just over 7,000 ft^3), they can haul freight at a cost 37 lower than the standard five-axle configuration and 32 percent lower than the current double 28's. As these are linehaul costs only, the inclusion of P & D, administration, and other costs would diminish these cost differentials somewhat. Nevertheless, the point remains that LCVs offer a significant opportunity for decreasing freight costs on the corridor.

6. FREIGHT SHIFTS

6.1 Introduction

In Section 4, it has been estimated that there is a annual total of 168 million tonnes of freight moved by truck along the corridor, representing 16.8 million truck trips. In addition, there are five to six million tonnes of rail freight moving in this corridor. [17] In this section an estimate is made of the amount of this traffic that might switch to LCVs if they were allowed to operate.

6.2 Intramodal Shifts

The most likely freight to shift to LCVs is the light density (< 400 kg/m^3) freight moving in large volumes over fairly long distances. Small shipments of light-density freight moving locally will continue to be handled by smaller trucks. Freight that fits this category includes parcels (ie, the courier-type trucking companies), LTL carriers, and some TL carriers (for commodities such as some food products, automobiles, and various other light-density manufactured goods).

The figures shown in Table 13 summarize the estimates for the maximum and minimum number of trips and annual tonnages that might switch to LCVs. The first line shows the total trips on the corridor (from Table 9), and the next two lines reduce this number to:

- tractor-semitrailer and train configurations: other configurations (straight trucks, truck-plus-trailers, etc.) do not haul freight that would switch to LCVs.
- configurations with van bodies or configurations used to haul automobiles: it is primarily freight in these two body styles that would switch to LCVs (ie, as compared to dump, flatdeck, stake and rack, etc equipment).
- tractor-semitrailers and/or trains with less than seven axles: configurations with seven or more axles are used to haul dense (say over 400 kg/m^3) freight.
- trips of 200 km or more in length: for shorter trips, LCV operations are not feasible.

The data for all four of these assumptions has been developed from the 1983 MTC survey (see Section 4). There is a further assumption, of course, that these province-wide trip characteristics apply to corridor trips: this is reasonable in that corridor trips probably account for three-quarters of all trips in the province (Section 4.4). The effect of these assumptions is as follows: out of the total of 45,918 daily truck trips on the corridor, about 8,194 may be carrying the type of freight suitable for LCV operations. On line 4 these truck trips are converted to annual tonnes, using 10 tonnes per trip as an average for current truck activity as in Section 4.5; rather than the 9.8 tonnes per trip average in the MTC survey.

It is estimated (line #5) that as much as 25 percent of the 29.9 million tonnes of traffic moving in five and six-axle combination trucks with van and/or auto-hauling trailers on trips over 200 kilometres may switch to LCVs. This 25 percent is roughly in line with the percentages developed in the FHWA study for the larger general freight truckers and the larger shippers. [18] Admittedly, the differences in freight characteristics and road characteristics between the two (the Quebec-Ontario corridor versus a US LCV network) warrants some caution in wholesale acceptance of these FHWA estimates; however, there being no other figures available, this estimate of 25 percent is used here as a rough estimate of maximum traffic volumes that might shift to LCVs.

The estimated minimum annual tonnes (lines 6 to 12) use the current tonnes handled by LCVs in Quebec to estimate a market share in Quebec intraprovincial trucking and, hence, the potential total tonnes on the corridor. Because freight characteristics in Ontario are different than in Quebec (a higher proportion of light-density manufactured goods), the 0.97 percent market share has been doubled to produce a minimum LCV market estimate of 4.4 million tonnes.

To summarize, it is estimated that out of a total annual volume of 167.6 million tonnes of truck freight moving on the corridor, 4.4 to 7.5 million tonnes will switch to LCVs (2.6 to 4.4 percent of the total).

A second question concerning intramodal shifts is the speed of the adjustment. The Quebec experience gives some insights. In less than three years, all Quebec general freight firms which had permit authorities from the Quebec Transport Commission used the LCVs on a daily basis. In other words, the shift to LCVs will probably be rapid.

Maximum Estimate	
1. Daily truck trips on corridor (Table 9)	45,918
2. Trips accounted for by vans and/or auto-carriers in tractor-semitrailer and/or train configurations with fewer than seven axles (38.5%)	19,194
3. Trips over 200 km (46.3%)	8,194
4. Annual tonnes (millions) (8,194 X 365 X 10)	29.9
5. Estimated maximum LCV potential (25%)	7.5
Minimum Estimate	
6. StatsCan, 1985, total intra-Quebec flows (million tonnes)	49.4
7. Add estimate of non-surveyed domestic flow	12.4
8. Total	61.8
9. 1985 LCV traffic (Table 3) (50,000 tonnes/month X 12)	0.6
10. LCV market share (line 9/line 8)	0.97%
11. Total Que/Ont flow (Table 9)	223.5
12. LCV annual potential (0.97% X 2)	4.4

Table 13 Estimated Intramodal Shift

The shift will be encouraged by two other factors. First, as information on the benefits of LCVs is now well known and as many carriers involved on the corridor have experience with LCVs (in Quebec, Western Canada, or the United States), the industry will want to make the shift as rapidly as possible. Second, with the pending deregulation of trucking, the pressures on the industry to cut costs and/or compete for market share will intensify and thereby speed the process of adjustment.

Offsetting the factors encouraging a rapid shift to LCVs, there are two possible impediments: equipment and labour availability. Equipment may not be a major problem as there are many shorter doubles now in existence, as the modifications required for some semitrailers is a matter of a minor retro-fit, and as there is equipment available from other jurisdictions. Driver shortages may be more serious (carriers would be required to use skilled drivers under the most likely special-permitting, insurance, and other requirements of a LCV scheme).

6.3 Intermodal Shifts

The presence of LCVs on the corridor, by decreasing the relative price of truck to rail, may divert traffic from the railways.

Theories on diversion have evolved considerably during the last thirty years. There have been three stages. The first, the comparative-cost approach, was developed by those working on the misallocation of resources in the transportation industry caused by the ICC regulations in the United States. [19] The claim was that rate regulation diverts traffic and, therefore, has an economic cost owing to the misallocation of resources. This is based on a comparative-cost analysis of intermodal competition. They write: "if railroads could take advantage of their technology by consolidation and abandonments, and follow a pricing policy more closely tied to marginal costs, the probable result would be a substantial diversion of traffic from highway back to rail". [20]

If the costs for moving a certain class of freight are less for railroads than for motor carriers, then from the standpoint of economic efficiency, this traffic should be carried by railroads. Under de-regulation, railroads would price at their long-run marginal costs and would undercut truck rates. However, since there are service differentials between rail and truck, long-run marginal costs are adjusted upward by a factor called a service differential. Most attention is focused on measurement of marginal costs, and comparatively little thought is given to estimating the economic value of the service differentials.

The two main weaknesses of the comparative-cost approach are: first, the service advantage of truck over rail is not fully captured by differences in lot size and average transit time; second and more important, the comparative-cost approach implicitly assumes that all shippers have identical preferences for the various attributes of transport services.

In the second stage in the evolution of theories on traffic diversion, there was an attempt to overcome the weaknesses of the comparative-cost approach by modelling shipper behaviour. [21] In choosing from a set of alternatives, shippers consider a variety of characteristics such as price, speed, reliability, loss and damage, experience and flexibility of service. Their decisions may also be affected by special attributes of the shipment such as unusual perishability, fragility, size and by their own shipper characteristics such as location, past transport behaviour and other socio-economic variables. The utility to a shipper of a given mode, therefore, can be described with a stochastic utility function which can be separated into two parts -- a function of observed data and a random variable.

This model of shipper choice, which can be estimated with a linear logit model, approaches the predictions of traffic shifts resulting from a policy change such as deregulation by estimating econometrically the price sensitivity of shippers' mode of transport selections. However it has been shown recently that linear logit models are inappropriate to simulate traffic allocation across modes under an alternative pricing scenario. [22] The main reasons are that they impose many rigid a priori restrictions on the parameters of price responsiveness of demand, such as the elasticities of substitution and the cross-price elasticities and that the structure of technology (or preference) underlying the linear logit models is severely irregular and inconsistent.

The third and last stage in the evolution of theories on traffic diversion is the modelling of the demand for freight transportation. [23] The starting point of this approach is that, as transportation is used as a factor of production, the demand model should be derived from the shipper's underlying production or cost function. A shipper, who maximizes his profits by producing the optimal amount of output is also motivated to use optimal combinations of various modes of freight services, the characteristics of which differ from one mode to another and from one link to another. Therefore, a shipper's demand for each mode of freight service with the given requirements for his product in various locations can then be derived from the shipper's production and distribution technology by minimizing the total cost of production and transportation. The main conclusions from this approach, although general, are the following: i) both price and qualities (speed, reliability) of demand vary substantially from commodity to commodity and from link to link; ii) elasticities of substitution between the railway and truck modes are greater than one for all commodity groups; and, iii) it is possible to identify the ranges over which effective rail-truck competition exists by computing the (Hicksian) own-price elasticities of the two modes. For example, the truck mode tends to dominate the traffic moving up to about 400 miles, while traffic moving further than 1800 miles is largely dominated by the rail mode. Therefore effective intermodal competition is likely to exist on those links with a distance between 400 and 1800 miles.

It is to be expected, then, that the railways operating on the corridor, the distance between Quebec City to Windsor being around 750 miles, will experience an increase in competition because of the LCV. This competition will affect primarily the piggyback and container service.

For this study, CP and CN Rail computed their losses if LCVs were permitted on the corridor. To do so, they partially reproduced a methodology developed when answering a previous request by RTAC on the potential impact upon their activities if vehicle weights and dimensions were changed and standardized across the board in Canada. [24] This methodology is a variant of the comparative cost approach. The combined estimate of the two railways is that 2.89 million tonnes of rail traffic would switch to LCVs, for a combined revenue loss of $96 million.

This estimate by the railways may be on the high side of actual intermodal shifts. First, the estimates overstate the loss incurred because the analysis implicitly assumed that all shippers have identical preferences over the various attributes of transport services (speed, reliability, loss and damage and so on). This assumption is too strong and binding in the real world. [25] [26] Second, the railway analysis assumes that, to meet LCV competition, rail rates could only be lowered to long run variable costs as defined under the CTC costing order. In practice the railways may have more pricing freedom than this (and, hence, retain more traffic).

While it is not possible to produce an independent estimate of the amount of rail traffic that would shift to LCVs, for present purposes the rail shift will be estimated at a maximum of 2.9 million tonnes (the railway's figure) and at a minimum 1.45 million tonnes (half the railway estimate).

6.4 Summary

The figures in Table 14 summarize the potential LCV market. As shown, there is an estimated 5.9 to 10.4 million tonnes of freight that may move on LCVs. This includes the high and low estimate for both intra- and intermodal shifts. Using the current experience in Quebec as a guide (LCVs average 20.7 tonnes per trip), these estimated tonnages represent somewhere between 285,024 to 502,415 annual truck trips. On a daily basis, this is 781 to 1,376 trips; some care has to be taken in comparing this with AADTT figures presented in Section 4.3 (1,500 to 2,500 combination trucks) as these LCV trips occur over the entire length of the corridor and not at a single point on the corridor.

	maximum	minimum
Annual truck traffic (million tonnes)	7.5	4.4
Annual rail traffic (million tonnes)	2.9	1.5
Total (million tonnes)	10.4	5.9
Annual truck trips (20.7 tns/trip)	502,415	285,024
Daily LCV Trips*	1,376	781

* Note: LCV trips occur at many points on the corridor; these are not AADTT estimates for a given point on the corridor.

Table 14 Estimated LCV Market

7. HIGHWAY COSTS

LCVs may have an impact on road costs. Bridge, geometry, capacity, and pavement costs are all affected by the type of trucks. In part this is because the original design criteria has to take into account the characteristics of trucks and in part this is because the road may wear out at a different rate when different trucks operate over it. Allocating road costs among different users (automobiles versus trucks, or one truck versus another) is both complex and contentious; no attempt is made here to untangle all the issues. No absolute estimate of the road costs associated with different vehicle types is made: "this truck imposes XX dollars of cost on the roads whereas this truck imposes only YY dollars of cost."

This level of detail is not needed to comment on the relative impact of different configurations. Rather, by considering the technical relationships between configurations and bridges, road geometry, road capacity, and pavements, some general observations may be made about the impact of LCVs in comparison to the trucks they would replace.

7.1 Bridges

Given that the potential LCVs would comply with the existing maximum GVW limits and the current load-spacing limits,* there would be no measurable impact on bridge costs.

To expand, a given LCV and a given current configuration are virtually identical in terms of bridge strength and bridge life. As long as both fit within the total load and load-spacing regulations, and as long as the bridge has been built to the design loadings from which the regulations are based, there is no difference when one or the other configuration passes over the bridge. Second, to the extent that the use of LCVs diverts traffic from rail to road, and therefore increases the frequency of bridge loads, this increased frequency has little material impact on bridge life.

7.2 Geometry

Vehicle characteristics (height, width, length, braking characteristics, centres of gravity, power/weight ratios, etc.) determine in part the geometric design standards for roads. To the extent that LCVs have different characteristics than traditional configurations -- the most obvious one being overall length -- it might be expected that the introduction of LCVs will affect the cost of building roads or, possibly, rebuilding parts of the existing corridor -- in particular, access ramps (horizontal and vertical alignment), interchanges on access roads (lane widths, etc.), staging areas (including rest stations), etc.

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* In Ontario, the load-spacing aspect of the regulations -- how much can be carried by axles measured over a longitudinal distance -- is controlled by the "Ontario Bridge Formula." In Quebec, this aspect of the regulations is controlled by a series of permitted loads, and load-reduction penalties, given certain minimum axle spacing requirements.

Indeed, as the FHWA study noted, there would be substantial additional costs associated with the introduction of LCVs in the United States, particularly in considering the adequacy of current highway interchanges, the access to urban and some rural areas, and in some cases the grades on highways in mountainous states. [27] More recently, Hutchinson has examined the impact of large trucks on urban roads and found some problems with existing truck configurations and current geometric design standards (for example, negotiating intersections). [28]

These two sources, while not addressing the specific issue of the impact of LCVs on the existing four (or more) lane divided highways in Quebec and Ontario, suggest that there is a cost associated with the use of LCVs (a "cost" if the roadway is modified, presumably a "problem" if it is not). But almost all of the "problems" in both of these sources relate to LCVs (or just large trucks in the case of Hutchinson's work) off the corridor highways; that is, on the access ramps or access roads.

There are two important points to note. First, no information on the design standards of the corridor have been obtained nor has there been any examination of the requirements of particular LCVs (a 9-axle turnpike double with axle spacings of __ , etc.) Clearly, then, no conclusions can be reached about the particular geometric road costs associated with permitting LCVs on the corridor. (It is not know if there were any "costs" and/or "problems" associated with the introduction of LCVs in Quebec, or for that matter in three Western provinces.)

The second point concerns the mechanism by which LCVs are allowed to operate -- special permits. The granting of these permits provides an obvious opportunity to internalize any geometric road costs that arise. This principle is used in Saskatchewan to permit heavy bulk haulers to operate trucks in excess of the normal GVW limits: the trucker and/or the shipper is assessed an additional fee to cover any incremental road (primarily pavement) costs associated with the haul. [29] In the case of LCVs on the Quebec-Ontario corridor, there is a similar opportunity to attach fees to these special permits (ie, in cases where operations under the permit necessitate any modifications to access ramps or roads, or modifications to rest areas, or the building of staging areas, etc.)

7.3 Capacity

Highway capacity, and the need (cost) to add to capacity, depends on traffic. Given a desired service level, engineers use standard procedures to measure traffic and in doing so to convert the number of trucks in the traffic stream to "passenger car equivalents."

Even without precise numbers it is obvious that a fewer number of LCVs are required to carry the same amount of freight as conventional trucks; therefore, it seems safe to estimate that LCVs would actually reduce the capacity problem. But to put this on a more solid foundation, the figures in Table 15 show how the estimated LCVs compare with existing volumes of traffic. (The method used compares existing truck traffic with potential LCV traffic including any traffic shift from the railways.)

	maximum	minimum
1. Total Annual Trips (Table 9)	16,760,000	16,760,000
2. Potential LCV traffic from existing Trucks (Table 13)(tne)	7,500,000	4,400,000
3. Potential LCV trips in conventional trucks (10 tne/trip)	750,000	440,000
4. LCV trips (Table 14)	502,415	285,024
5. Change in trips (line 3 - 4)	-247,585	-154,976
6. Percent Change (line 5/line 1)	-1.5%	-0.9%

Table 15 LCVs and Corridor Capacity

Total estimated truck trips on the corridor (from Table 9) are shown on line #1. The freight on line #2, the "truck-shift" portion of the estimated LCV market, requires 440,000 to 750,000 conventional truck trips annually (10 tonnes/trip, including empty trips). However, if LCVs handled this freight plus the estimated 1.5 to 2.9 million tonnes of rail traffic with 20.7 tonnes/trip, it would only require 285,024 to 502,415 trips per year. The reduction of 154,976 to 247,585 trips represents 0.9 to 1.5 percent of total truck traffic on the corridor highways.*

There are rough edges to this analysis: the figures imply a uniform reduction in truck trips all along the corridor (unlikely); the analysis ignores temporal considerations (time of day, day of week, etc.); and, the implication is that these LCV trips have the same impact on traffic (hence capacity) as current configurations (also unlikely). Even admitting these rough edges, the analysis is sufficient to suggest that the direction of the expected impact is to reduce traffic and, hence, capacity requirements.

7.4 Pavements

Pavement performance, pavement life, and the cost of pavement, are influenced by a range of factors: climate, quality of materials used, drainage, maintenance practices, and vehicle axle loads. It is the last item, axle loads, which receives most of the attention by those considering the impact of large trucks (in particular, LCVs) on the roads.

There is a debate about the impact of different axle loads on pavements. [30] Without going into this, this analysis simply uses the conventional tools to show that some LCVs can move freight at the same or lower pavement cost than some conventional trucks.

An equivalency factor is used to reduce axle loads to a common base and thereby permit different trucks to be measured in terms of their impact on pavements. This can be referred to as an "EAL" (equivalent axle load), an

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* Assuming trucks average 20% of the traffic and 3 passenger car equivalents, this is a reduction in total traffic of between 0.5 and 0.9%.

"ESAL" (equivalent single axle load), or a "LEF" (load equivalency factor); for here, the term "LEF" is employed. Because there are various measures for these factors, two are used here simply in an attempt to see how sensitive the problem is to this issue of which equivalency factor to use.

The first of these is the "fourth power law" developed by AASHO. The exact equivalency factor used in designing a pavement will vary from one situation to another (different jurisdictions will have their own formulation, flexible and/or rigid pavements have different factors, etc.) For here, a proxy for the conventional LEF (on flexible pavements) is:

$$LEF = (X/9)^{3.8} \quad \text{for steering axles}$$
$$LEF = (X/18)^{3.8} \quad \text{for single axles}$$
$$LEF = (X/33)^{3.8} \quad \text{for tandem axles}$$

where "X" is the actual axle load, and 3.8 is used instead of the fourth power. The denominator in the equation is in "kips" (thousands of pounds). The curves produced by the these equations come close to those shown in any reference on the subject. In the following, this first LEF is referred to as "method #1."

The second LEF ("method #2") is based on the analysis of RTAC data by Bruce Hutchinson at the University of Waterloo. [31] As there were no front-steering axles in the analysis by Hutchinson, the LEFs shown for these axles under method #2 are identical to those shown for method #1.

In Table 16, a simple example of how these LEFs are used is shown. The truck is the standard five-axle tractor semitrailer with typical axle loads. According to method #1, these loads are equivalent to 4.9 LEFs (or, in simpler terms, 4.9 passes of an 18,000 pound axle). According to Hutchinson's formulation, this configuration is equivalent to 6.5 LEFs. At the bottom of the Table, these LEFs are converted to LEFs per 1,000 tonnes of freight which provides a simple way of comparing the effect of different configurations on pavements (and, hence, pavement costs). All else equal (climate, soil conditions, suspension systems, speeds, tires, method of converting axle loads to equivalency factors, etc.), a configuration with lower LEFs per 1,000 tonnes imposes less pavement cost per tonne of freight than a configuration with higher LEFs per 1,000 tonnes.

Typical 5-axle Tractor-Semitrailer (3-S2) (payload = 22.1 tonnes)

	front axle	drive tandem axle	semi-trailer axle	
load (tne)	5.0	16.5	16.0	= 37.5
LEFs - method #1	2.2	1.4	1.3	= 4.9
- method #2	2.2	2.2	2.1	= 6.5
LEFs/1,000 tonnes				
- method #1	= 221.7			
- method #2	= 291.9			

Table 16 Load Equivalency Factors -- Typical 3-S2

	GVW	Load	. . . Axle Loads/LEFs							Total
Freight at 100 kg/m3										
3-S2 48' semi	25.3	9.9	4.5	10.2	10.6					
- method #1			1.45	0.23	0.27					1.96
- method #2			1.45	0.61	0.68					2.74
3-S1-2 double 28's	27.4	11.5	4.0	10.4	5.0	4.0	4.0			
- method #1			0.93	0.25	0.16	0.07	0.07			1.47
- method #2			0.93	0.65	0.50	0.31	0.31			2.68
3-S2-2 Rky Mtn dble	35.2	15.7	4.0	10.0	9.2	6.0	6.0			
- method #1			0.93	0.22	0.16	0.31	0.31			1.92
- method #2			0.93	0.58	0.46	0.74	0.74			3.43
3-S2-2 Turnpike dble	42.1	19.9	4.5	12.6	12.0	6.5	6.5			
- method #1			1.45	0.52	0.43	0.42	0.42			3.24
- method #2			1.45	1.07	0.94	0.87	0.87			5.21
3-S2-4 Turnpike dble	44.1	19.9	4.5	11.6	10.0	9.0	9.0			
- method #1			1.45	0.38	0.22	0.14	0.14			2.33
- method #2			1.45	0.86	0.58	0.43	0.43			3.75
3-S1-2-2 Triple	37.3	17.3	4.5	10.0	4.8	4.5	4.5	4.5	4.5	
- method #1			1.45	0.22	0.13	0.10	0.10	0.10	0.10	2.21
- method #2			1.45	0.58	0.45	0.40	0.40	0.40	0.40	4.06
Freight at 200 kg/m3										
3-S2 48' semi	35.3	19.9	4.5	15.8	15.0					
- method #1			1.45	1.22	1.01					3.68
- method #2			1.45	1.98	1.73					5.15
3-S1-2 double 28's	39.0	23.1	4.5	14.5	7.0	6.5	6.5			
- method #1			1.45	0.88	0.56	0.42	0.42			3.73
- method #2			1.45	1.56	1.03	0.87	0.87			5.79
3-S2-2 Rky Mtn dble	50.9	31.4	5.0	15.5	15.0	7.7	7.7			
- method #1			2.16	1.14	1.01	0.80	0.80			5.92
- method #2			2.16	1.89	1.73	1.26	1.26			8.29
3-S2-2 Turnpike dble	61.9	39.7	7.5	18.0	17.9	9.3	9.3			
- method #1			10.09	2.01	1.99	1.61	1.61			17.32
- method #2			10.09	2.83	2.80	1.87	1.87			19.46
3-S2-4 Turnpike dble	63.5	39.3	7.0	15.5	15.0	13.0	13.0			
- method #1			7.77	1.14	1.01	0.59	0.59			11.09
- method #2			7.77	1.89	1.73	1.17	1.17			13.72
3-S1-2-2 Triple	54.6	34.6	5.0	15.0	7.3	7.3	7.0	6.6	6.6	
- method #1			2.16	1.01	0.64	0.64	0.56	0.43	0.43	5.87
- method #2			2.16	1.73	1.11	1.11	1.03	0.89	0.89	8.90

Table 17 LEFs: Conventional Configurations versus LCVs

In Table 17 the results of analyzing six configurations are shown. To standardize, each truck is filled to its cubic capacity by two types of freight: with a density of 100 kg/m^3, typical of parcel carriers; and with a density of 200 kg/m^3, typical of a general freight carrier (a 1980 US report [32] notes that general freight in that country averages 176 kg/m^3). Note that the nine-axle turnpike double "weighs out" before the cube is filled when loaded with freight at 200 kg/m^3 at Ontario weight limits. The first two configurations are typical of trucks used currently to carry the lighter general freight. The next four configurations are LCVs. In the case of the turnpike double, two possibilities are shown: the seven-axle turnpike double which represents an optimal vehicle design "on paper" given the current axle/GVW load limits; and the nine-axle turnpike double which seems to be the choice of most LCV operators in Quebec (see Section 2.3).

The front-axle loads in Table 17 have been selected on the basis of what would be regarded as "typical" by the trucking industry, given the weight and dimension regulations in Ontario. The effect of these regulations (unlike those in any other province) is to give front-axles a relatively high load at the higher GVWs. As the analysis of LEFs is sensitive to front-axle loads, the same calculations shown in Table 17 were re-done with all front axles held at 5,000 kilograms. (Strictly, this would violate Ontario regulations for some of the configurations shown -- roughly, any configurations shown with a GVW over 60 tonnes).

From Table 17 it is evident that LCVs impose a higher cost on pavements than do the current configurations. The figures in Table 18 summarize the information shown in Table 17, as well as the same calculations with standard five-tonne front axles.

	Light Density (100 kg/m^3)				Moderate Density (200 kg/m^3)			
	Method 1		Method 2		Method 1		Method 2	
		5 tne front		5 tne front		5 tne front		5 tne front
48' semi	1.96	2.62	2.74	3.37	3.68	4.25	5.15	5.70
double 28'	1.47	2.62	2.68	3.76	3.73	4.32	5.79	6.36
Rky Mtn dble	1.92	2.98	3.43	4.42	5.92	5.92	8.29	8.29
Turnpike (7)	3.24	3.83	5.21	5.78	17.32	10.95	19.46	12.66
Turnpike (9)	2.33	3.01	3.75	4.40	11.09	6.10	13.72	8.81
Triple	2.21	2.88	4.06	4.69	5.87	5.87	8.90	8.90

Table 18 LEFs -- Summary

To repeat, under either method of calculation, and with freight anywhere in the range of 100 to 200 kg/m^3, all LCVs have more LEFs than the conventional configurations they would replace. Truck for truck, then, LCVs do not compare favorably with the trucks now hauling light-density freight. However, LEFs for an individual truck are meaningless without considering the payload. The figures in Table 19 show the number of equivalent axle loads per thousand tonnes of freight for various configurations.

	Light Density (100 kg/m^3)				Moderate Density (200 kg/m^3)			
	Method 1		Method 2		Method 1		Method 2	
		5 tne front		5 tne front		5 tne front		5 tne front
48' semi	196.7	263.9	275.6	339.0	185.1	213.9	259.3	286.9
double 28'	127.3	227.5	232.5	326.4	161.6	187.4	250.9	275.7
Rky Mtn dble	122.3	189.9	218.7	281.4	188.4	188.4	264.2	264.2
Turnpike (7)	162.9	193.0	262.3	291.0	435.8	275.6	489.8	318.6
Turnpike (9)	117.3	151.7	188.6	221.3	282.2	155.2	349.2	224.3
Triple	128.0	166.7	234.7	270.8	169.6	169.6	257.3	257.3

Table 19 LEFs per 1,000 Tonnes

From these figures, LCVs generally deliver the lightest freight (100 kg/m^3) with less impact on pavements than conventional configurations. With freight approaching 200 kg/m^3, the picture is not as clear. In particular, where LCVs have to operate with high front-axle loads (7 tonne or higher) some of these configurations perform poorly. But, given more moderate front-axles (5 tonnes), three of the LCVs perform as well or better than current configurations. That is, all but the seven-axle turnpike double deliver 200 kg/m^3 freight with 155 to 188 LEFs per 1,000 tonnes (method #1) or 224 to 264 LEFs/1,000 tonnes (method #2), which is generally below the range of current trucks.

7.5 Summary

To summarize, there is no evidence to indicate that LCVs will change road costs significantly. Given that gross vehicle weights, axle loadings, and axle spacings will be held to the same limits as on conventional trucks, there is no measurable impact on bridges. Highway capacity will actually improve (fewer trucks), but the change is so small that it probably could not be detected. In most situations, the use of LCVs can reduce or at least not increase pavement costs. The major exception to this is where some of the LCVs, particularly the 7-axle turnpike double, are used with front-axles of seven or more tonnes, hauling freight approaching or above 200 kg/m^3).

The one ares where there may be some additional costs is in respect of geometric changes to ramps and access roads. (Rest areas on the highways may also be affected.) However, these costs could be borne by the holders of the special permits. That is, if a carrier wishes to apply for a permit allowing the operations of a LCV, and if the routes to be used require modifications (improved intersections on access roads, improved on and off ramps, wider lanes on access roads, etc.) a fee could be levied.

8. TRANSPORTATION COSTS

Table 20 shows the calculations of the total freight bill for traffic that might switch to LCVs. There are a number of variables:

Column #1: Potential LCV traffic (from Table 14) is estimated to be between 5.9 and 10.4 million tonnes.

Column #2: The analysis has been done with two freight densities (100 to 200 kg/m^3).

Column #3: The analysis is sensitive to the assumptions made about average shipping distances. In Table 20, three distances are shown. While the Ontario MTC data in Section 4.4 indicated a mean trip length of 345 km, for here the range of shipping distances is shown as 400 to 800 km. The LCV potential market (Section 6) was estimated considering only those trips in excess of 200 km which would have the effect of increasing the mean considerably.

1	2	3	4	5	6	7	8	9
Fore-	Freight	Ship.	Rail	Truck	LCV	Total Transport. Cost		
cast	Density kg/m^3	Dist. km	Cost /tne	Cost /tne	Cost /tne	Current $ mill	LCV $ mill	change %
MAXI-	100	400	33.17	36.00	24.00	366.2	249.6	-31.8
MUM	"	600	33.17	54.00	36.00	501.2	374.4	-25.3
	"	800	33.17	72.00	48.00	636.2	499.2	-21.5
	200	400	33.17	19.20	12.96	240.2	134.7	-43.9
	"	600	33.17	28.80	19.44	312.2	202.1	-35.2
	"	800	33.17	38.40	25.92	384.2	269.5	-29.8
MINI-	100	400	33.17	36.00	24.00	208.2	141.6	-32.0
MUM	"	600	33.17	54.00	36.00	287.4	212.4	-26.1
	"	800	33.17	72.00	48.00	366.6	283.2	-22.7
	200	400	33.17	19.20	12.96	134.2	76.5	-43.0
	"	600	33.17	28.80	19.44	176.5	114.6	-35.0
	"	800	33.17	38.40	25.92	218.7	152.9	-30.1

Table 20 Freight Transportation Cost

Column #4: Rail costs per tonne ($33.17) are computed directly from the information supplied by CN and CP Rail (2,893,500 tonnes of lost traffic with an associated revenue loss of $95,976,300). A point to bear in mind when considering the figures in Table 20 is that the average length of haul (or ideally the distribution of hauling distances) for this rail traffic is not known. Therefore, comparisons of the rail costs per tonne with the truck costs can be misleading.

For example, comparing the rail cost of $33.17 per tonne with the current truck cost of $19.20 per tonne (freight with a density of 200 kg/m^3 at a shipping distance of 400 km) and concluding that truck is

cheaper than rail is incorrect. It may well be that the rail cost is based on less dense freight (thereby increasing the cost per tonne) and on freight moving considerably further than 400 km (again, increasing the cost per tonne).

Column #5: Current trucking costs are based on the figures shown in Table 12 -- $0.075 per tonne-kilometre for freight with a density of 100 kg/m^3 and $0.040 for freight with a density of 200 kg/m^3. To make these truck linehaul costs more comparable with rail costs (rates), the figures used in Table 20 have been increased by 20 percent over those shown in Table 12 (ie, a mark up to account for administration costs).

Column #6: LCV costs are also based on Table 12 (plus 20 percent), using as a rough average of the three LCVs shown a cost of $0.050 per tonne-kilometre for the least dense freight and $0.027 for the denser freight. (These costs are just slightly above the turnpike double costs.)

Columns #7, #8, & #9: The final three columns show the cost of the total freight bill. Column #7 has been computed on the basis of the "truck-shift" traffic from Table 14 times the appropriate current truck cost per tonne plus the "rail-shift" traffic times $33.17 per tonne. Column #8 has been computed by simply multiplying the total potential LCV traffic times the relevant LCV cost per tonne. The final column shows the percentage change. Note that in these calculations, there is one over-simplification: a certain portion (0.6 million tonnes) of the traffic on the corridor is already moving on LCVs (in Quebec). To this extent, the reductions in transportation costs shown in Table 20 overstate the case.

There are several qualifications to the analysis shown in Table 20. First, it is a simple "before/after" analysis that assumes an instantaneous switch to LCVs; there is no attempt to discount any future stream of annual savings back to present values. Second, it ignores potential off-setting costs: road-costs (judged to be insignificant in Section 7); or costs imposed on other rail shippers (assuming current rail "LCV-shift" volumes were moving at rates above their long-run-marginal costs and that the railways are unable to reduce the scale of their plant, rates for other rail shippers may have to be increased).

Depending on the assumptions about shipping distances and freight densities (and to a lesser extent the mix of current and LCV trucks), there is clearly a significant reduction in freight transportation costs along the corridor. The figures shown in Table 20 suggest a savings of anywhere from $62 to $137 million dollars.

9. ROAD USER TAXES

For 1986, Ontario and Quebec collected the following taxes from road users (in millions of dollars): [33]

	Ont.	Que.	Total
registration taxes	393.2	247.6	640.8
gasoline & fuel tax	1,199.5	1,384.6	2,584.1
TOTAL	1,592.7	1,632.2	3,224.9

To calculate the impact on registration taxes of allowing LCVs to operate on the corridor, a number of variables were used:

- Maximum and minimum freight forecasts (Table 14).
- Alternative assumptions about trips distance (400, 600, and 800 kilometres). These assumptions were used to convert the estimated number of trips (by current trucks or by LCVs) to an estimate of annual distances.
- Alternative assumptions about average annual kilometres per tractor (140,000, 160,000, and 180,000). These assumptions were used to convert the estimated annual distances to an estimate of the number of tractors required (current or with LCVs operating).
- Alternative assumptions about the average GVW of the tractors (current or LCV). This assumptions was used to calculate the total registrations taxes payable.
- Alternative assumptions about tax regimes. In reality, some of the current tractors that would be replaced by LCV tractors would be registered in both provinces (and, possibly, elsewhere). Further, the registration taxes payable would be prorated under CAVR between the two provinces according to distances driven for those tractors operating extraprovincially. Rather than introduce this degree of complexity into the analysis, a simpler approach was adopted. Registration taxes were calculated <u>as if</u> the entire fleet of tractors were based in Ontario and paying 100 percent of their taxes to Ontario (ie, no prorate); then the same calculations were made <u>as if</u> the tractors were all Quebec-based. The "correct" estimation of the impact on registration taxes lies somewhere between these two points.

The result of all of these calculations was a spread sheet with over 300 possible answers. Since this is too many to show here, a selection of some of the results is shown in Table 21. The following provides one specific example of how the figures on Table 21 were calculated:

- <u>Parameters</u>:
  i) Maximum Freight Forecast (750,000 current truck trips handle 7.5 million tonnes of freight; 502,415 LCV truck trips handle 10.4 million tonnes of freight)
  ii) Ontario tax regime.

iii) Average trip distance is 600 kilometres and average tractor usage is 160,000 kilometres per year.

iv) The average GVW shifts from 45 tonnes (current trucks) to 63.5 tonnes (LCV trucks).

	Trip Distance	GVW shift	Annual Tractor Usage (km) 180,000	160,000	140,000
1. Assuming Ontario Tax Regime					
MAXIMUM FORECAST	400	40 - 50	-0.06%	-0.07%	-0.08%
		45 - 60	-0.04	-0.05	-0.06
		45 - 63.5	-0.02	-0.02	-0.02
	600	40 - 50	-0.09	-0.10	-0.12
		45 - 60	-0.06	-0.07	-0.08
		45 - 63.5	-0.09	-0.03	-0.03
	800	40 - 50	-0.12	-0.14	-0.16
		45 - 60	-0.09	-0.10	-0.11
		45 - 63.5	-0.09	-0.10	-0.11
MINIMUM FORECAST	400	40 - 50	-0.04	-0.05	-0.06
		45 - 60	-0.03	-0.04	-0.04
		45 - 63.5	-0.03	-0.04	-0.04
	600	40 - 50	-0.07	-0.07	-0.08
		45 - 60	-0.05	-0.06	-0.07
		45 - 63.5	-0.05	-0.06	-0.07
	800	40 - 50	-0.09	-0.10	-0.11
		45 - 60	-0.07	-0.08	-0.09
		45 - 63.5	-0.07	-0.08	-0.09
2. Assuming Quebec Tax Regime		Axle Shift			
MAXIMUM FORECAST	400	5 - 6	-0.04%	-0.05%	-0.05%
		6 - 6	-0.20	-0.22	-0.25
	600	5 - 6	-0.06	-0.07	-0.08
		6 - 6	-0.30	-0.33	-0.38
	800	5 - 6	-0.08	-0.09	-0.11
		6 - 6	-0.39	-0.44	-0.51
MINIMUM FORECAST	400	5 - 6	-0.03	-0.04	-0.04
		6 - 6	-0.12	-0.14	-0.16
	600	5 - 6	-0.05	-0.05	-0.06
		6 - 6	-0.19	-0.21	-0.24
	800	5 - 6	-0.06	-0.07	-0.08
		6 - 6	-0.25	-0.28	-0.32

Table 21 Estimated Change in Registration Taxes

- Current tractors are 2,813 ((750,000 X 600)/160,000) paying a total of $5.2 million in registration taxes (2,813 X $1,863)

- LCV tractors are 1,884 ((502,415 X 600)/160,000) paying a total of $5.1 million in registration taxes (1,884 X $2,690)

- The difference in registration taxes of $171,728 is 0.03 percent of the total registration taxes collected in 1986 by the Quebec and Ontario governments.

It is clear from the figures shown in Table 21 that under any reasonable range of assumptions, the change in registration taxes is very small.

The changes in fuel taxes were calculated in a similar fashion. Under the same range of assumptions used to calculated registration taxes (average trip distance varying from 400 to 800 kilometres), total truck distances changed by an amount of 62 to 198 million kilometres. Assuming an average fuel consumption rate for current tractors of 45 litres per 100 kilometres and a fuel consumption rate of 55 litres per 100 kilometres for tractors used in LCV operations (see Table 11), the total tax change would be as follows:

- At Ontario's tax rate of $0.099/litre = $1.6 to $4.8 million

- At Quebec's tax rate of $0.1245/litre = $2.1 to $6.1 million

These amount to 0.06 to 0.24 percent of the total fuel (gasoline and diesel) tax collected by both provinces.

To summarize, Quebec and Ontario now (1986) collect $3.2 billion in registration and fuel taxes. If LCVs were allowed to operate, these taxes would decrease by less than one percent. Given a range of reasonable assumptions, the actual decreases have been estimated as follows:

		millions of dollars	
registration taxes	-0.02 to 0.51%	0.13	3.27
fuel taxes	-0.06 to 0.24%	1.55	6.20
		1.68	9.47

10. CONCLUSIONS

Recent US and Canadian studies (FHWA and RTAC) have observed that there are productivity advantages available through the use of LCVs. This is not surprising; as in other modes of transportation, larger vehicles can haul freight at lower unit costs than smaller vehicles. Further evidence of the productivity advantages of LCVs is available from the fact that 22 North American jurisdictions (including four Canadian) now allow their use.

The most likely LCVs to be used in Quebec and Ontario would give the trucking industry 31 to 72 percent more cube than the most common current configurations. For example, the turnpike double has 199 cubic metres compared to the current double 28's 115 cubic metres.

This increase in cube (at the current axle and GVW limits) would allow LCVs to move lighter density freight at a cost 24 to 37 percent lower than conventional five-axle tractor-semitrailers, and 18 to 33 percent lower than the common double 28-foot combinations now operating on the corridor. (These reductions vary considerably from one situation to another.)

In terms of potential markets, the available data makes a precise estimate difficult. The best guess is that 5.9 to 10.4 million tonnes of freight (annual) might shift to LCVs. This includes an estimated 1.5 to 2.9 million tonnes of freight now moving on the railways. The total of 5.9 to 10.4 million tonnes is 3.5 to 6.2 percent of the estimated volumes of truck freight now moving over the corridor (168 million tonnes). This volume of freight could be handled by between 781 to 1,376 LCV trips per day. (As these trips are spread over the entire length of the corridor, the number of LCVs observed at any particular point would be considerably less than this.)

Allowing LCVs on the corridor would have a minimal impact on highway costs. Bridge, geometric, and capacity costs on the corridor would be largely unaffected; pavement costs could actually decrease although the impact of LCVs is probably so minimal that any changes would be hard to detect. There could be some highway costs associated with access ramps, access roads, and rest and/or staging areas. No estimate of these possible costs has been made. However, the mechanics of allowing LCVs (special permits) opens up an opportunity for internalising these highway costs. Applicants for LCV permits could be required to pay for any additional costs associated with roadway improvements on the access roads and/or ramps that would be used. This type of policy (for different types of trucks) is already used in one Canadian province.

The impact of LCVs on road-user taxes in Quebec and Ontario is too small to be significant ($2 to $9 million). In contrast to the very minimal impact on road costs and road-user taxes, the use of LCVs on the corridor would allow freight transportation costs to drop by $62 to $137 million.

While some aspects of LCV use require further study, this research has demonstrated there is a clear economic reason for allowing the use of LCVs.

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   "- LCVs currently operated have very low accident rates, but this safety record cannot necessarily be extrapolated because of the special conditions that govern their operation [eg, the existing LCVs are operated under special permit, by large, safety-conscious firms].

   - Performance and handling limitations of LCVs, as well as their higher gross weights, could prove to create significant problems if LCVs are used more generally, such as under a greater variety of roads, environmental, and traffic conditions.

   - An LCV network limited to interstate highway links would divert some freight to these relatively safer highways from lower-level roadways and thus could decrease accident rates on the lower-level roadways.

   - A given amount of highway travel by LCVs can move more freight than the same amount of travel by conventional vehicles and thus accident rates per ton mile could be reduced if current LCV accident rates did not worsen.

   - We simply do not know whether LCVs can be operated safely in general use." (pp. S-5 - S-6)

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